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A DIVISION OF
FLIGHTEX FABRICS INC.
CAMBRIDGE, MASS.

PRODUCT PROCESS Engineering

REPORT NO. 3-8-50G-1

MONTHLY PROGRESS REPORT

ENGINEERING PROGRAM FOR THE

DEVELOPMENT OF A LIGHTWEIGHT

ANTI-TANK ROCKET

FOR THE PERIOD

MONTH OF MARCH 1958

CONTRACT NO. RD-142

~~ORDNANCE PROJECT NO~~

~~DEPT OF ARMY PROJECT NO~~

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HESSE - EASTERN DIVISION

FLIGHTEX FABRICS, INC.

PROGRESS REPORT #7

ENGINEERING PROGRAM FOR THE DEVELOPMENT OF A LIGHTWEIGHT ANTI-TANK ROCKET

MARCH 1958

CONTRACT NO. RD-142

PREPARED BY Thomas F.
Project Engineer

APPROVED BY Charles B. W.
General Manager

SUBMITTED BY: HESSE-EASTERN DIVISION
FLIGHTEX FABRICS, INC.
CAMBRIDGE, MASSACHUSETTS

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WORK DONE DURING THE MONTH OF MARCH 1958

REPORTING PERIOD 7 MARCH - 4 APRIL 1958

SYSTEM EVALUATION PROGRAM

With the completion of tests and engineering work during this period, the project is moving into its final stages. Up until the end of March, the main effort was directed toward developing an item which will fulfill the requirements and to run a sufficient number of tests to check out the item. At this point the over-all item has been developed. There are still certain problems to be overcome. However, these problems are in all cases of a minor nature. Particular attention to detail will be employed from here on in order to arrive at the optimum weapon system configuration when orders are being placed for a final lot of components.

The problems remaining are:

1. Choice of warhead.
2. Graze sensitivity.
3. Ignition.
4. Manufacturing methods used to obtain motor bodies.

MOTOR DEVELOPMENT PROGRAM

Photograph No. 63 shows the motors which have been supplied from

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our subcontractor. As mentioned in the February Report, a great deal of difficulty was experienced in forming the nozzle section of the motor. It proved to be impossible to obtain the expansion cone used on E. M. No. 1. The motor shown in the photograph has approximately half as much of an expansion cone as E. M. No. 1. The difficulties in manufacture continued well into March and have resulted in more than three weeks' delay in the delivery of motors for E. M. No. 2. Other sources of supply and methods of manufacture were investigated. It appears that it will be possible to manufacture the motor of E. M. No. 2 as per drawing by changing the supplier. In order to utilize the motors obtained from our present supplier, it was necessary to add an expansion cone. Scrap parts from a parallel program are being used to obtain the expansion cone (see Photograph No. 64).

The angle of this expansion cone is slightly smaller than the angle in the motor design for E. M. No. 2. The cone has to be cut off in order to bring the largest diameter and the length of the round into conformity with E. M. No. 2. Two cones were used in tests on 27 March 1958 (Nos. 126 and 127). In order to keep the fuze tests schedule on time, motors without expansion cones (see Photograph No. 63) were used for fuze testing. Round Nos. 126 and 127 were fitted with the complete cone without prior re-machining. The result was a cone approximately 3/4 of an inch longer than called for in the design. The result of using this excessive cone combined with out-of-launcher burning of the round was an extreme case of thrust malalignment resulting in a vertical attitude.

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Round Nos. 114, 115, 116, 117, 128 to 133 used percussion ignition with a M29 primer. No problems were encountered in operating the primer with the firing pin (see launcher section). The following is a tabulation of dynamic motor tests during the reporting period. It has to be stated that heavy walled motors were used for Round Nos. 80 through 113. These rockets were fired primarily for fuze testing, and the result as far as the motor is concerned can be used to evaluate ignition only. Round Nos. 114 through 127 used no additional expansion cone and folding fins attached to the launcher area by means of drive screws (see Photograph No. 65). The remaining rounds (Nos. 128 through 133) were fired with rivetted folding fins and the additional expansion cone (see Photographs Nos. 70).

(See Pages 4 and 5 for tabulation of Dynamic Motor Tests)

DYNAMIC MOTOR TESTS

D - Delayed Ignition
OB - Burning Outside Launcher
Inc.- Incomplete Ignition
PS - Percussion Steel Launcher
PP - Percussion Plastic Launcher
PT - Plastic Tubing Only
* - Large Expansion Cone

Date	Round	Igniter	Velocity	Attitude	Ignition	Target
3/11	80 Amb.	Mod. II	---	OK	OK	Graze
	81 "	"	---	OK	OK	Plate
	82 "	"	---	"	"	Graze
	83 "	"	---	"	"	"
	84 "	"	---	"	"	"
	85 "	"	---	"	Inc.	"
	86 "	"	---	"	Inc.	"
	87 "	"	---	"	Inc.	"
	88 "	"	---	"	OK	"
	89 "	"	---	"	OK	"
	90-94	"	---	"	OK	"
	95 Amb.	"	---	"	Inc.	"
	96 "	"	---	"	Inc.	"
3/13	97-113	"	---	"	OK	"
						10 X 10 Ft. Target at 100 Yds.
3/27	114+ PS	Mod. II	335	Good	Delay	Over
	115+ PS	"	400	"	OK	"
	116- PS	"	400	"	Delay OB	"
	117- PS	"	400	Tilted	"	Under
	118+	"	400	Good	OK	High
	119+	"	390	Good	OK	High
	120+	"	235	"	Delay OB	Under
	121+	"	380	"	Slight D	Low
	122-	"	350	"	Delay OB	Over
	123-	"	380	"	"	High
	124-	"	340	"	"	High
	125-	"	285	"	"	Under
*	126+	"	---	"	OK	Plate
*	127-	"	---	Vertical	OB	Plate

Date	Round	Igniter	Velocity	Attitude	Ignition	Target
3/27	128 PT	Mod. III Squib	330	Good	Too Much Pressure	Low
	129 PT	"	200			
4/4	130- PS	Mod. II With Alum. Powder	200	Motor Fails	Too Much Pressure	Low
	131- PS	"	165	Good	"	"
	132- PP	"	220	Good	"	"
	133+ PP	"	200	Good	"	"

NOTE: Nos. 85, 86 and 96 igniter Model II was used as is. Three grams of additional black powder were added loosely to all remaining rounds.

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EVALUATION OF TEST RESULTS

It may be stated that all rockets with proper ignition obtained satisfactory attitude and velocity. There are still problems to be solved in obtaining proper ignition, and it is suspected that the motor body of Round No. 130 failed because of excessive blow-out pressure. Model 2 igniter was modified by increasing the wall of the powder cup. Delayed and incomplete ignition was experienced on a number of rounds prior to Round No. 128. Model 3 igniter designates the igniter design with a heavier wall. Round Nos. 128 through 133 did not obtain satisfactory velocity, and fragments of propellant which were found in the launcher and in the area behind it would indicate that the blow-out pressure from this igniter is excessive. Since aluminum powder had been added to the black powder in those rounds (Nos. 128 through 133), the possibility of excessive pressure being caused by the addition of aluminum powder will have to be checked out by firing igniter Model 3 without the addition of aluminum powder. Motor bodies recovered after successful flight have shown slight bulging with no evidence of cracking.

FUTURE PROGRAM

1. Elimination of ignition problems; establishment of satisfactory ignition at both extremes of temperature.

2. Accuracy tests to establish the accuracy and exterior ballistics of the rocket.

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3. Ordering of 500 or more rocket motor bodies in order to make them available for final testing.

WARHEAD DEVELOPMENT PROGRAM

The test set-up was improved so that solid 9" X 10" steel plates were used and great care was taken to insure flatness of the plates and proper support. The tests of the 25 E. M. No. 1 head bodies with heavy wall double angle liner have been continued, and the results can be seen from the following table:

STATIC PENETRATION TESTS, HEAVY DOUBLE ANGLE LINER

Date	Rd. No.	Roll-out Diameter	Charge Wt.	Density	Penetration	Xray
3 Mar	1	.007	466.3	1.59	8"	OK
	2	.009	460.3	1.57	7 1/2"	Very small cavity over apex
	3	.004	462.5	1.575	10"	OK
	4	.006	463.5	1.58	9"	OK
	5	.005	462.8	1.575	3"	OK
	6	.002	460.1	1.57	6"	Cavity over apex
	7	.008	467.3	1.595	6"	Small cavities on both sides of cone
13 Mar	8	.004	463.2	1.58	10 1/4"	"
	9	.003			9"	No picture

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(Continued)

Date	Rd. No.	Roll-out Diameter	Charge Wt.	Density	Penetration	Xray
13 Mar	10	.004	465.7	1.59	9 1/4"	Cavity over apex
	11	.005	459.3	1.565	10"	Very small cavity level with apex of cone
	12	.003	452.1	1.54	9 1/2"	OK
	13	.006	452.7	1.545	6 1/2"	Cavity over apex
	14	.004	459.0	1.56	8 3/4"	"
	15	.007	459.7	1.57	8 1/4"	OK
	16	.008	457.3	1.56	9 1/4"	OK
	17	.005	464.6	1.585	9 1/4"	Very small cavity over apex
	18	.003	456.7	1.555	8 1/4"	OK
	19	.005	461.9	1.58	13 3/4"	OK
	20	.009	462.7	1.585	12 1/4"	OK
	21	.007	460.5	1.575	7 1/4"	OK
	22	.007	462.5	1.58	12 1/4"	Very small cavity over apex
	23	.006	456.6	1.555	9 1/2"	Oblong cavity over apex
	24		454.9	1.55	9 1/4"	OK
	25		454.4	1.55	9	OK

Stand-Off: Round Nos. 1 - 5, 4"
Round Nos. 6 - 25, 3"

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This tabulation includes the tests already reported in last month's progress report (Round Nos. 1 to 7). The second portion of this test was conducted on 13 March. With the exception of Round Nos. 5, 6 and 7, it may be stated that all penetration has been in excess of 6" in armor, i.e., in excess of the minimum contract requirements. There appears to be only a vague correlation between the cavities observed in the Xrays and the penetration achieved. It is planned to conduct further tests with this liner and with the 3" stand-off. A correction of the stand-off distances given in last month's report is in place at this point. The 2 3/4" and 3 3/4" figures for stand-off given in this report refer to the distance between the bottom of the skirt and the plate. Since stand-off is usually measured from the bottom of the cone to the plate, these figures should read 4" and 3", respectively. Twenty-five head bodies of E. M. No. 2 have been shipped to Eastern Tool Company for assembly. The following test procedure will be followed:

Five heads will be tested using the 1 1/2" booster and the 3" stand-off.

Five using the 3/4" booster and 3" stand-off.

Five using the best of the above boosters and a 3 3/8" stand-off.

The remaining ten heads will be assembled with a single angle cone.

This cone is currently being developed by Eastern Tool Company making use of as much of the M31 tooling which is available to them as possible. Single angle liners will be fired as follows:

Five at 5 1/2" stand-off and 5 at 4 1/2" stand-off.

It is planned to revise the ogive design based on the data obtained from the above tests. Twenty-five head bodies will be manufactured, in accordance with the results and fired dynamically prior to final freezing of the design.

FUZE DEVELOPMENT PROGRAM

INTRODUCTION

The lead backed inertia elements which have given satisfactory results on static tests have been dynamically tested. Forty-nine rockets fired during the reporting period contained a fuze. The result of this testing is as follows:

The tests indicate that a working fuze has been achieved, although some minor modifications may still be required to obtain a sufficient margin of safety against the bouncing conditions. A problem appears to exist on graze functioning. So far as can be determined from testing conducted, there is no difference in functioning or graze sensitivity between the 6 ball and shroud type of design.

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FUZE TEST - APRIL 1958

* Exceptionally Long Ignition Delay
** Vertical Attitude of Round
*** Motor Failure
S Shroud
D Double Ball

Date	Round	Fuze	Safety	Type Test	Vel.	Weight	Arm	Safety	FUNCTION
3/11	80	S	---	Graze	---	1445.3	Yes	---	NO
	81	S	---	Plate	---	1483.5	"	---	Yes
	82	S	---	Graze	---	1477.6	"	---	Yes
	83	D	---	"	---	1478.6	"	---	No
	84	D	---	"	---	1494.6	"	---	No
	85	D	---	"	---	1496.6	"	---	Yes
	86	D	---	"	---	1455.9	"	---	No
	87	D	---	"	---	1456.2	"	---	No
	88	S	---	"	---	1485.1	"	---	No
	89	S	---	"	---	1495.3	"	---	Yes
	90	S	---	"	---	1486.3	"	---	Yes
	91	S	---	"	---	1458.3	"	---	Yes
	92	S	---	"	---	1488.6	"	---	Yes
	93	D	---	"	---	1503.1	"	---	Yes
	94	S	---	"	---	1475.9	"	---	No
	95	S	---	"	---	1482.8	"	----	No
	96	S	---	"	---	1487.3	"	---	Yes
	97	S	---	"	---	1485.8	"	---	Yes

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(Continued)

Date	Round	Fuze	Safety	Type Test	Vel.	Weight	Arm	Safety	FUNCTION
3/13	98	S	---	Graze	---	1280.6	Yes	---	Yes
	99	D	---	"	---	1266.8	"	---	Yes
	100	D	---	"	---	1183.6	"	---	Yes
	101	D	---	"	---	1269.6	"	---	Yes
	102	D	---	"	---	1272.0	80%	---	No
	103	S	---	"	---	1273.0	Yes	---	No
	104	S	---	"	---	1270.5	"	---	Yes
	105	D	---	"	---	1289.4	"	---	Yes
	106	D	---	"	---	1281.0	"	---	Yes
	107	S	---	Plate	---	1429.1	"	---	Yes
	108	S	---	"	---	1439.0	"	---	Yes
	109	D	---	"	---	1504.1	"	---	Yes
	110	D	---	"	---	1461.8	"	---	Yes
	111	S	---	"	---	1450.8	"	---	Yes
	112	S	---	Graze	---	1445.7	"	---	Yes
	113		---	Graze 35 Ft.	---	1445.8	80%	---	
3/27	114+	D	Des. 1	100 Yd. Accur.	335	1483.0	No	Safe	
	115+	D	"	"	400	1485.0	No	Safe	
	116-	D	None	"	400	1481.0	Yes		No
*	~~117-~~	~~D~~	~~None~~	~~"~~	~~400~~	~~1496.0~~	~~80%~~		

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(Continued)

FUNCTION diagram?

Date	Round	Fuze	Safety	Type Test	Vel.	Weight	Arm	Safety	[redacted]
3/27	118†	D	Des. 1	100 Yd. Accur.	400	1490.0		Safe	
	119†	D	None	"	390	1495.0	Yes		Yes
	120†	D	None	"	235	1493.0	Yes		No
	121†	D	None	"	380	1496.0	Yes		Yes
	122-	D	None		350	1483.0	Yes		Yes
	123-	D	None	100 Yd. Accur.	386	1475.0	Yes		Yes
	124-	D	None	"	340	1484.0	Yes		Yes
	126†	D	None	Plate		1584.0	Yes		Yes
**	127-	D	None	"		1588.0	No		No
4/4 ***	130-	D	Des. 2	100 Yd. Accur.	200	1450.0	No	Safe	
	131-	D	"	"	165	1470	Yes		Yes

With the exception of Round Nos. 102, 113, 114, 115, 117, 118 and 130, all fuzes tested set back, latched and armed. Fuzes in Round Nos. 80, 83, 84, 86, 87, 88, 94, 95, 103 and 120 did not trigger when grazing the earth.

DESCRIPTION OF TEST

The first part of the fuze test was planned to be conducted

against steel plate at 40 feet from the end of the launcher. However, after firing one round against the steel target, it was found to be impossible to re-use the motor body. The motor bodies for the fuze tests had heavy walls in order to re-use them. The test set-up was therefore changed and the rounds fired for graze. The launcher was depressed so that the rounds hit the earth as indicated in the test tabulation. Two rounds hit either the earth or the target at 35 feet from the launcher - Round Nos. 102 and 113. These rounds were found to be incompletely armed, the rotor having turned 80 per cent of its rotation.

The second part of the test was a combination of functioning and accuracy tests. Some of the rounds hit the mound behind the 100-yard target. Some went over the target and grazed the earth at 300 yards from the launcher. Some grazed the earth before the 100-yard target was reached because of faulty ignition.

Round Nos. 114, 115 and 118 used the design shown in previous reports. The fuzes did not release their safety locks, and all three were found in the safe condition when recovered. It was found that the safety pin had left a brinneling mark on the rearward face of the safety groove in the fuze housing. In analyzing the problem, it was found that a cocking condition exists between the triggering components, the safety sleeve, the safety pin and the fuze housing. This necessitates a force larger than the spring used to withdraw the pin, and it brings up the problem of variation in the required force.

A new design was developed with the object of eliminating this

condition. Photograph No. 66 shows the change in the groove in the fuze housing and a new safety pin. No spring is used to withdraw the safety pin. The 45° angle in the fuze housing matches a similar angle on the safety pin. When the fuze housing and the triggering components move back, the safety pin is cammed out. This action is prevented by the safety sleeve as long as the round is in the appropriate position in the launcher. Two fuzes using this design (Design No. 2) were dynamically tested on 4 April (Round Nos. 130 and 131). Because of ignition problems, a motor failure occurred on Round No. 130. The fuze could not arm and remained safe. Round No. 131 functioned properly, and the fuze operated upon hitting the target.

Additional tests with this design are required to obtain statistical proof of functioning. However, static tests seem to indicate that this design will work reliably and safely.

The lack of graze sensitivity shown in these tests is being investigated and greater clearances were given the triggering sleeves starting with Round No. 114 in order to facilitate the forward motion of the sleeve when the target is hit. Round No. 117 shows a typical "bounce condition". This condition has not been found in any of the other rounds. It is the same condition in which the fuze that was recovered from the dynamic test on 5 February was found. In the course of conducting this test, one more fuze from the dynamic test in February that had been lost in the snow at the time was found. The rocket (117) had very poor ignition and burned outside the launcher. Burning was spasmodic. The possibility of oscillation instead

of even acceleration exists in this case. It was in the same condition, i.e., the rotor had turned only a very small increment of its rotation, and the firing pin had been released. There is no evidence of any difference in functioning or graze sensitivity between the shroud type and double ball type fuze. Since a large number of double ball type components are available and since the certainty of functioning with the double ball should be greater in theory, the double ball design will be used to complete the test program of E. M. No. 2. The dynamic fuze test program will have to be halted until satisfactory ignition has been obtained.

STATIC TESTING

Static tests have been conducted with an increase in the height of the drop to 30 feet, and the drop fixture was improved so that the test capsule was allowed to fall with less interference. The result of the change in test conditions was that the large number of bounce-type malfunctions reoccurred. The object of this static testing was to find whether greater graze sensitivity could be produced by using a lighter firing spring. However, the greater number of malfunctions encountered lead us to abandon this attempt. The possibility of placing sand in a small plastic capsule attached to an inertia element to deaden the impact of the inertia element upon the base of the fuze is being investigated. Another possibility of improving the bounce condition consists in placing two or more additional C springs into suitable grooves in the inertia element and decreasing the internal diameter of the fuze housing in the appropriate places in order to obtain a breaking effect immediately prior and upon

impact of the inertia element with the base of the fuze. Additional functioning tests will be conducted with the more loosely-fitting triggering sleeves to obtain further proof of functioning.

FUTURE PROGRAM

Additional functioning tests will have to be conducted to further assure functioning with improved graze sensitivity. Tests with the modified safety pins will be conducted as soon as possible. Upon completion of these tests, arming distance and dynamic penetration tests will be conducted.

LAUNCHER DEVELOPMENT PROGRAM

The launcher was further improved during the month by redesigning the handle as a result of a human engineering study. Photograph No. 67 shows the launcher handle in its present shape. This handle can be readily manufactured from plastic, and all parties have agreed that it is a suitable design.

The front sight was checked out against a 100-yard target and finalized.

The design of the igniter was changed to incorporate the M29 primer instead of the .22 blank cartridge.

Two steel launchers complete with inner sleeves were used for checking out the complete firing system in dynamic tests. (Round Nos. 114, 115, 116, 117, 130 and 131 - see Dynamic Motor Tests tabulation). A minor modification has been necessary in order to support the cross piece which

contains the obstructing pin. A safety pin which prevents the cross piece from releasing has been incorporated in the design and has greatly facilitated the loading of the system. All rocket tests were satisfactory, i.e., the triggering mechanism worked, and the primer initiated the black powder charge in the igniter. Round Nos. 132 and 133 were fired from a prototype launcher using the plastic tubing. The same launcher was used for both rounds. The inner sleeve which provides a step-off for the fuze was made of aluminum and had a thinner wall than called for in the final design. Round Nos. 128 and 129 were fired using electric ignition and the plastic launcher tubing without any inner sleeve only. Both rounds started on their flight path without effecting the plastic tubing. A hydrostatic test was conducted on the plastic tubing, and it was found that the bursting point of the tubing was reached at a pressure of 1400 pounds per square inch. This pressure exceeds the design pressure by a considerable safety margin. A redesign of the cross piece has been started as a result of the experience gained in assembling the weapon systems described above. This new design will not change the operating principles of the launcher and firing mechanism in any way. It will merely improve ease of assembly and strength of the components. It is planned that as a result of the tests conducted during March a final lot of launcher components will be ordered from the Eastern Tool Company. The launcher program appears to be on schedule providing that the ignition problems which have been encountered (see Motor section) can be solved within the next few weeks.

The engineering effort on the launcher will now turn toward the

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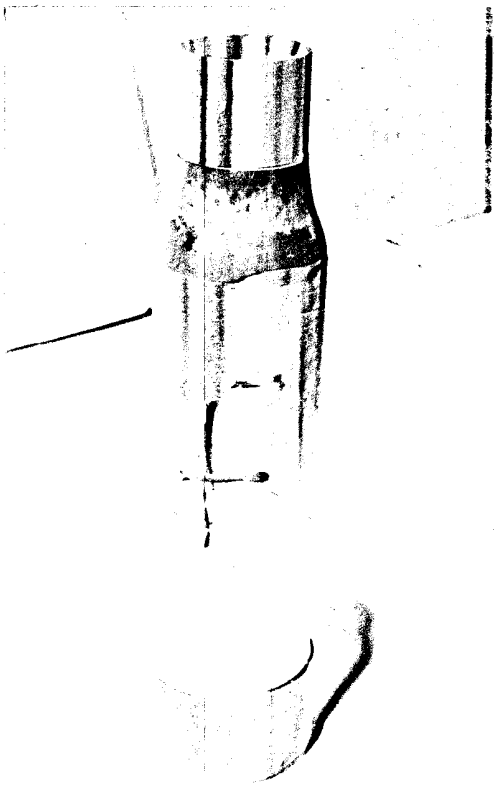
problem of packaging. The number of rounds contained in one package, the design of the end plug, waterproofing, drop tests, etc., will have to be conducted in order to complete the program.

Thomas F.
Project Engineer

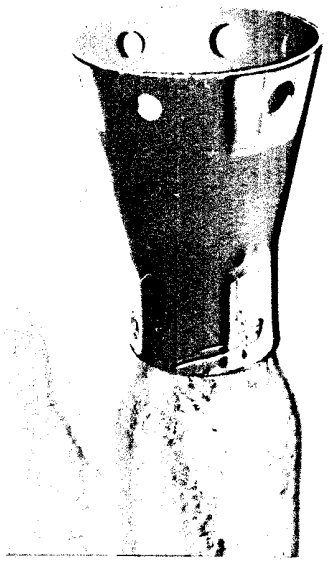
Evaluated vs. costs expended for the month

$12,467.70

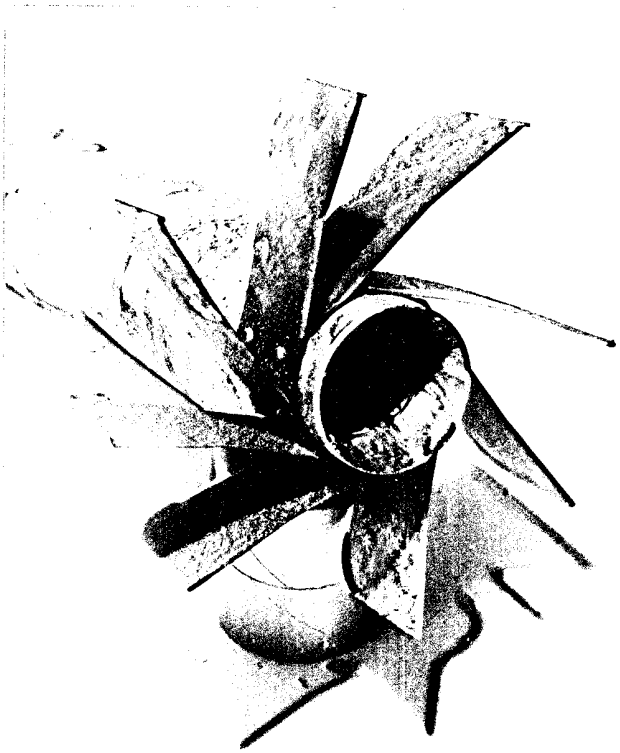
Charles B.
General Manager



Photograph No. 63
Motor Body with Incomplete Expansion Cone



Photograph No. 64
Salvaged Expansion Cone

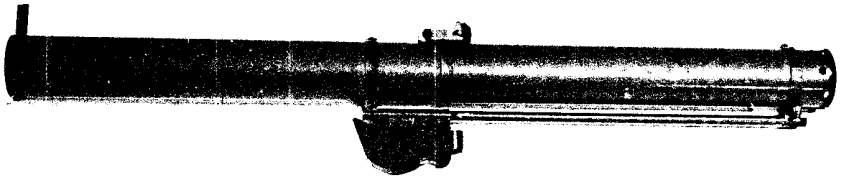


Photograph No. 65
Fins Attached by Means of Drive Screws

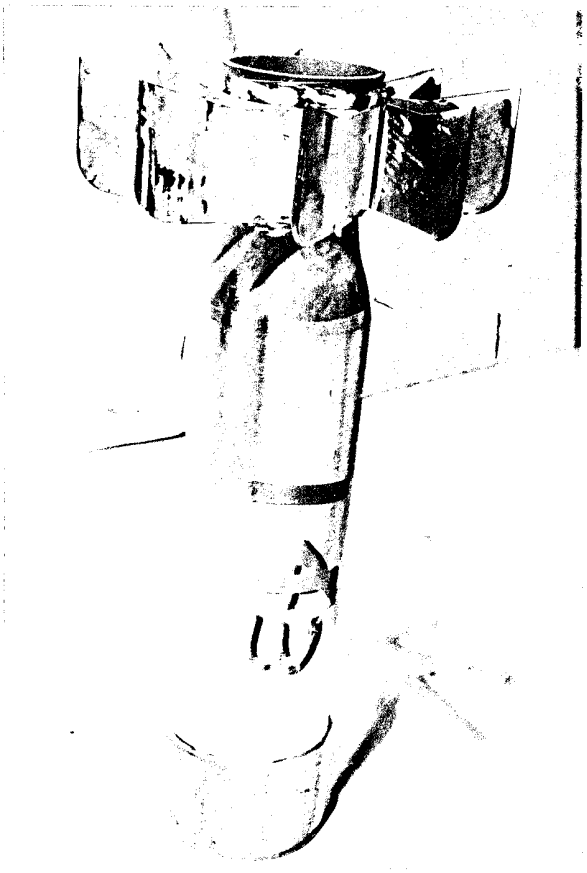
Photograph No. 66
Redesigned Groove In Fuze Housing

Photograph No. 67
Redesigned Plastic Launcher Handle

Photograph No. 68
Launcher Open



Photograph No. 69
Launcher Closed



Photograph No. 70
Complete Motor With Expansion
Cone and Fins